Development of Heat Transfer Diagnostics for ALPS

Sandia Team
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ALPS-HT Team
Sandia, ANL, UCLA
others (overlap with APEX)

Work in progress:

- preparation of liquid metal loop for EBTS
- preparation of heated Li pool for EBTS
- preparation for IR measurements on Li

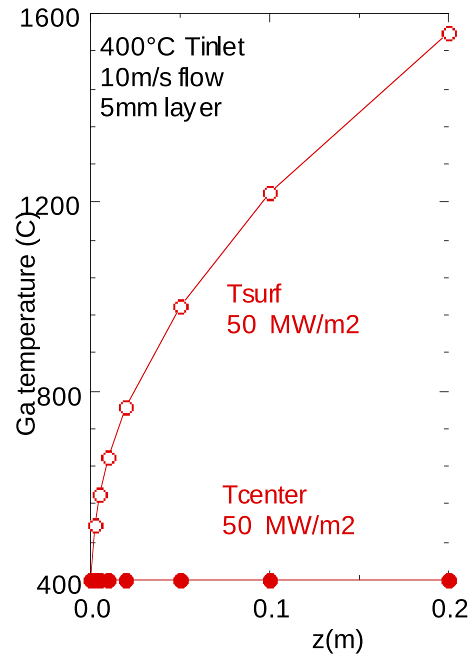
ALPS - Power Density

MHD suppresses turbulence in liquid metal.

A critical issue for liquid metal PFCs is how to increase the transfer of heat from the heated surface to the bulk fluid, as by 2-D turbulence or internal rotation in droplets.

In PFCs for APEX and ALPS, developing flow from nozzles is important.

Modeling these effects is a challenging computational problem.



The most productive approach is likely a combination of testing and analyses. For both, we need to develop tools.

Analysis: **3-D models, MHD effects in developing flows.**

Tests: **techniques to measure surface temperature distributions in fast moving fluids.**

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- ***The full 3-D MHD analysis of a divertor or experiment is difficult.***
- ***A "complete" heat transfer experiment is large and expensive.***

"Full" Conditions:

vacuum
free surface flow (v>10m/s)
heat (neutral beam)
heat rejection (HX)
B>3T (s.c. magnets)

MHD issues:

developing flow
(inlet/outlet, bends, ∇B)
nozzle model
2-D turbulence
turbulence enhancement

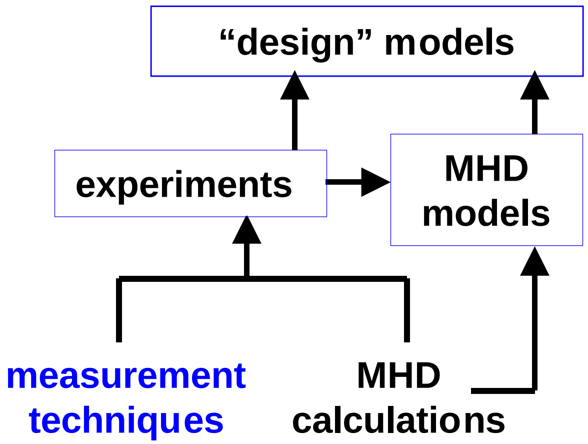
Measurement issues:

fast moving surface
spatial resolution (s=1mm)
time resolution (s/v<100μs)
emissivity (ε >0.1, IR software)

Approach:

- tools for MHD calculation
- appropriate diagnostics

Find a "good way" to do simple heat transfer tests. Proceed to larger experiments.



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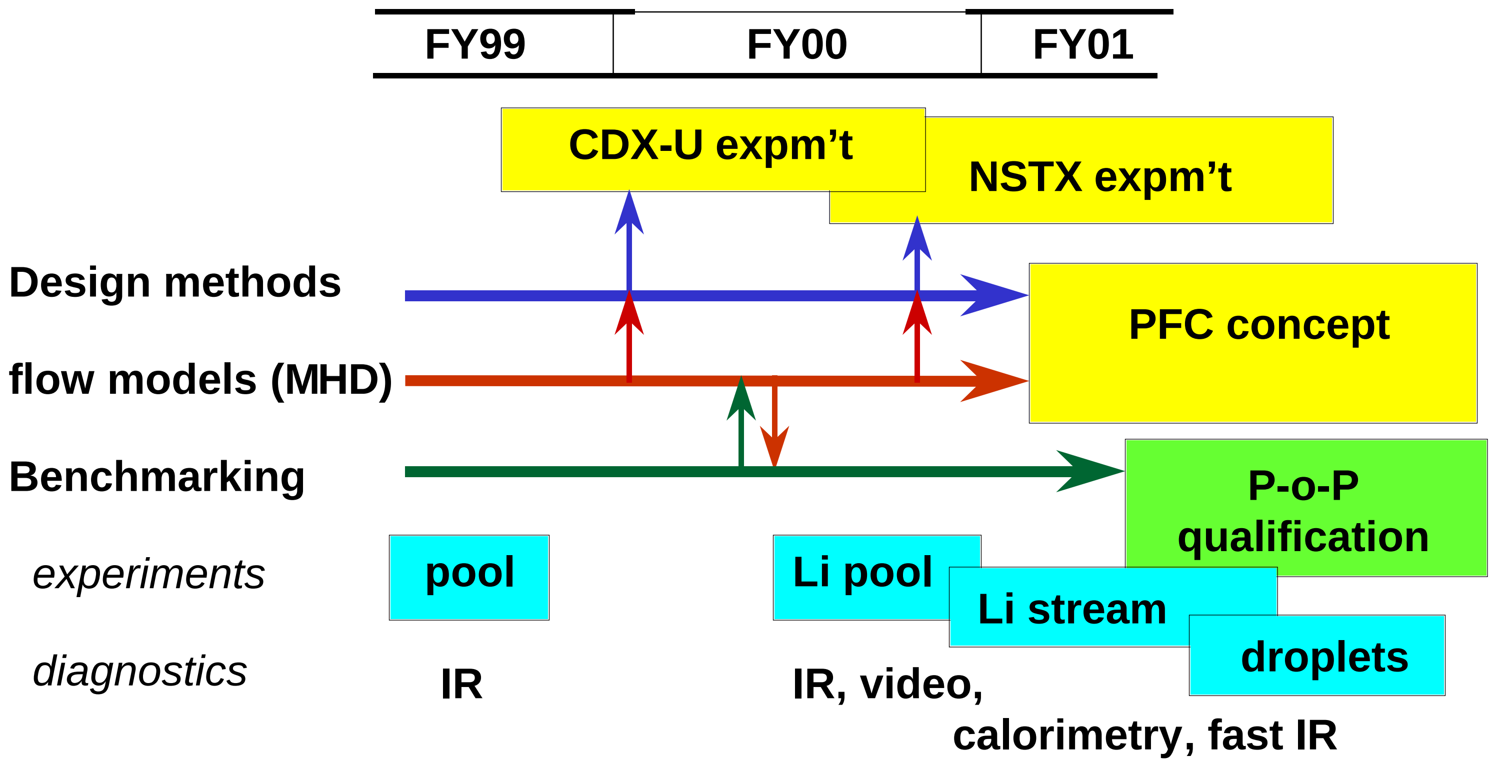
Heat Transfer & Thermal-Hydraulics for ALPS

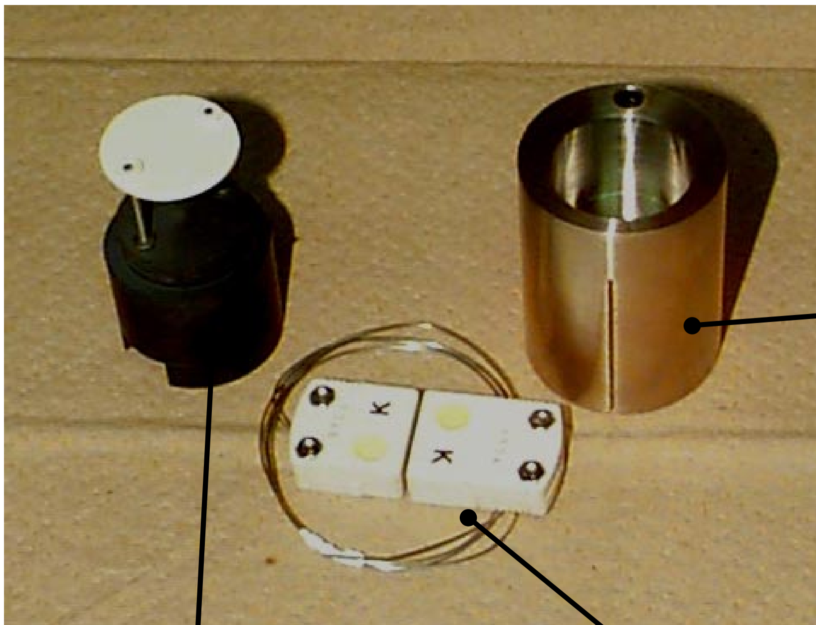


Develop Measurement Techniques

Objectives:
calibrate IR image
compare test with FE thermal model

Materials:
Ga pool (1999)
Sn pool (1999)

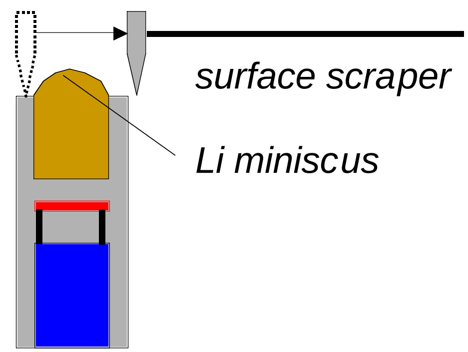
Li pool, new boat (2000)



316SS boat
"black hole" for IR calibration
recess on bottom for heater

heater element with support and standoff

thermocouple (in SS boat)



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Prepare Li Loop for EBTS

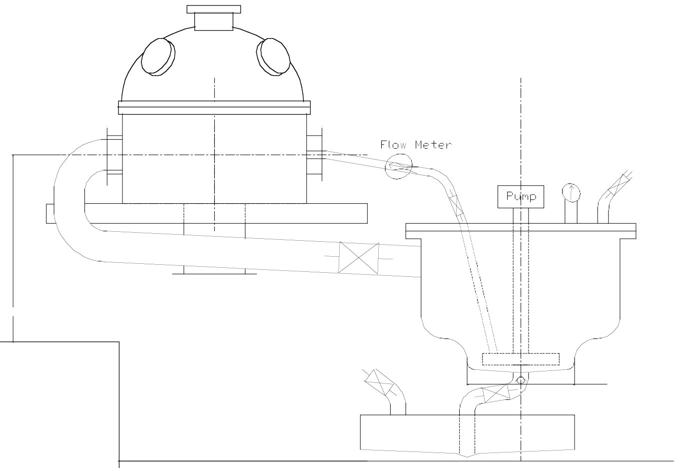

Photo of chamber

- Chamber is ready and will be used for Li pool test
- Bids are being negotiated for Li loop (heated pot, pump, piping, collection basin, vacuum and controls)
- Nozzle and catcher system is in development.

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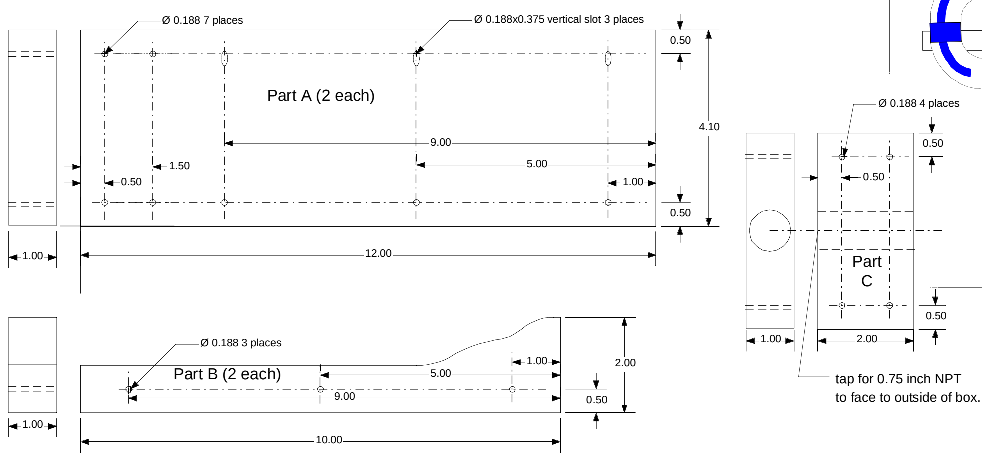
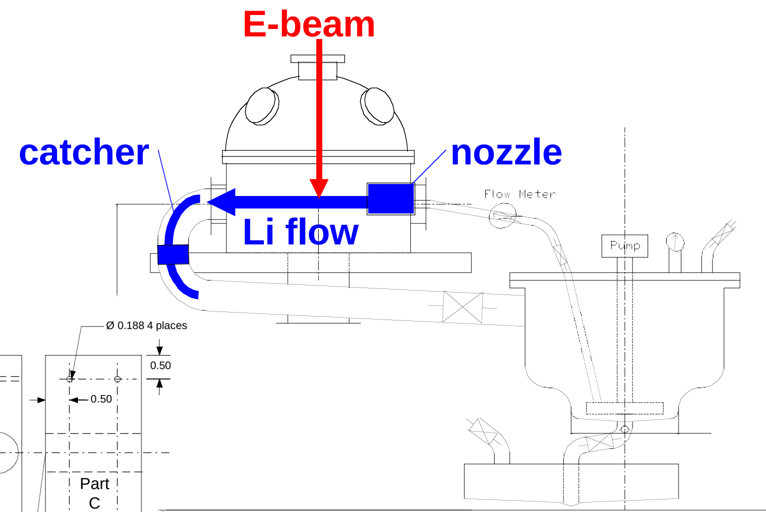
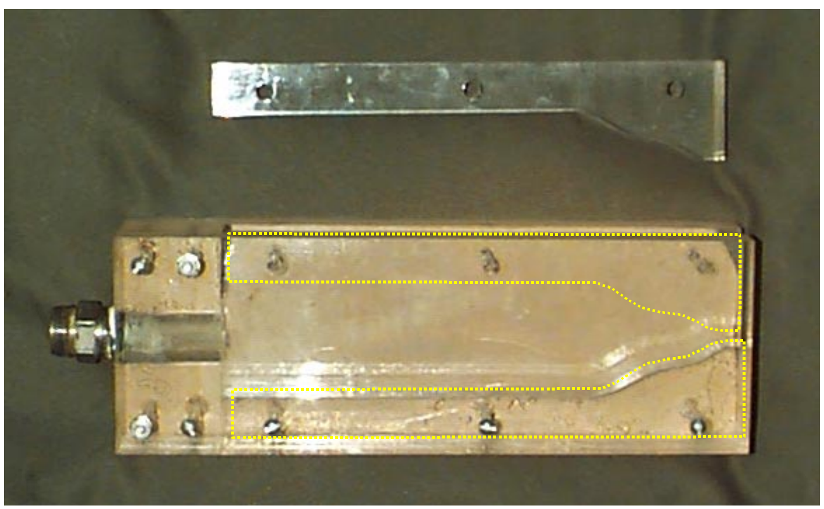
Prepare Li Loop for EBTS





- ***We started with a design by JAERI and Osaka U. for a Li loop for IFMIF testing.***



- **We made a polished plexiglass model. (Reservoir was packed with tubes to provide flow straightening.)**
- **In our initial tests, streamlining with the nozzle cross section was lost in <10cm.**
- **We hope to collaborate with UCLA on an improved nozzle design.**

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Calibration & Calorimetry:

A Challenge for LM Surface Heating Experiments

3mm Sn drop/stream/film passes through a 20mm thick SOL at 10m/s (1ms) and absorbs 20MW/m^2.

A droplet absorbs ~0.14J. T_{bulk} (thermalized) rises 44ºC.

A stream absorbs ~2.4J. T_{bulk} (thermalized) rises 9.4ºC.

For a film, T_{bulk} (thermalized) rises 7.4ºC.

We want to measure temperature distributions.

In a droplet or stream ejected from a nozzle, spin affects the surface heat distribution.

In a droplet or stream or film, turbulence (2-D) affects the heat flow.

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Calibration & Calorimetry:
A Challenge for LM Surface Heating Experiments

Basic features:	flow velocity, v	5-20 m/s
	spatial resolution, s	1-2 mm
	desired acquisition time >.5s/v	50-100μs
IR TV rastor, f = 30 frames/s,		1/f=33ms
IR line scan mode, f = ~1800 line/s		1/f=~500μs

We are planning heating tests with streams/ramps and droplets (no B-field) to develop thermal measurement techniques.

We are exploring possibilities for future tests with B-field.

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